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Feed-in tariff outlook in Malaysia

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ABSTRACT

This paper aims to present the feed-in tariff (FiT) outlook in Malaysia, which is in the process of being enacted through a Renewable Energy (RE) Policy by the Government of Malaysia (GoM). A brief in policies leading towards the RE policy and the potential of each RE sources under FiT mechanism have been discussed. The successful utilisation of RE source in electricity generation and the FiT implementation globally are positive indicators to implement FiT in Malaysia. Potentials of FiT on biomass, biogas and solid waste energy are currently very promising in Malaysia, but it is solar energy which is predicted to be the main RE of the future, surpassing all other REs.

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1. Introduction

Malaysia is a country in the Southern Asia which comprises Peninsular Malaysia and East Malaysia separated by the South China Sea. Malaysia's framework in energy development started when petroleum was found in the early 1970s. In 17 August 1974, Petroliam Nasional Berhad (Petronas) [1] was incorporated under the Companies Act 1965. Petronas is wholly-owned by the GoM and is vested with entire ownership and control of petroleum resources in Malaysia through the Petroleum Development Act 1974. Other successive policies include the National Petroleum Policy 1975, National Energy Policy 1979, National Depletion Policy 1980, Four Fuel Diversification Policy 1981, Fifth Fuel Policy 2000, National Biofuel Policy 2006 and recently, National Green Technology Policy 2009. The most important step towards sustainable development is when the Fifth Fuel Policy was introduced in 2000 where biomass, biogas, municipal waste, solar and mini-hydro were recognized as potential RE sources in electricity generation. From thereon, other new policies are directed towards utilisation of RE and promotion of energy efficiency in order to reduce over-dependence on fossil fuels and at the same time achieving sustainable development.

In the coming Tenth Malaysia Plan (10MP) 2011–2015, a RE policy 2011 is expected to be launched. RE policy and action plan by the GoM have been presented by the Malaysia Energy Centre or Pusat Tenaga Malaysia (PTM) with the aim to enhance the

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utilisation of RE resources towards national electricity supply security and sustainable socio-economic development [2]. Five main objectives are: (i) to increase RE contribution in the national power generation mix, (ii) to facilitate the growth of RE industry, (iii) to ensure reasonable RE generation cost, (iv) to conserve environment for future generation, and (v) to enhance awareness on the role and importance of RE.

Recently, the prime minister of Malaysia, Datuk Seri Najib Razak has confirmed that the government is in the process of instituting a RE law [3] and one of the new mechanism is the FiT. The introduction of FiT is set to change Malaysia's electricity production through RE. Everyone (domestic users and industrial users) will be able to generate renewable electricity through RE such as biomass, wind, solar and sell it back to the national power grid at a premium rate [4]. Section 2 introduces the concept of FiT and an earlier small scale implementation of the mechanism through the Small Renewable Energy Power programme as well as the coming full FiT mechanism. Section 3 presents the potential of each RE source under the FiT mechanism and Section 4 talks about the global RE and FiT scenario. Lastly, the conclusions.

2. Feed-in tariffs: past and future

FiTs are RE payments of electricity in kilowatt-hour (kWh). It promotes exportation of electricity as a form of investment. Two separate meters are to be installed by the users: (i) the users' monthly billings are paid to the utility on one meter and (ii) the users' electricity exported to the distribution grid receives payment from the utility on another meter.

Small scale FiTs have been implemented in Malaysia in the Small Renewable Energy Power (SREP) programme. SREP programme was launched by GoM in May 2001 to encourage and intensify the utilisation of RE in power generation. Small power generation plants which utilise RE such as biomass, biogas, municipal waste, solar, mini-hydro and wind can apply to sell electricity to the utility through the distribution grid system. The mechanism was established through the RE Power Purchase Agreement (REPPA) on selling electricity by RE project developers and purchase by the national utility companies. The RE electricity producers will be given a license of 21 years effective from the date the plant is commissioned. Capacity of a small RE plant exceeding 10 MW is allowed but only a maximum 10 MW power can be exported to the distribution grid. The GoM has set up a Special Committee on RE (SCORE) under the Ministry of Energy, Communications & Multimedia to speed up the effort. SREP programme was targeted to contribute 5% (600 MW) of the country's electricity demand by 2005 but despite various efforts and incentives, only two plants (i.e. Jana Landfill at Puchong, Malaysia using biogas with 2 MW installed capacity and TSH Bio-Energy Project at Kunak, Sabah using biomass with 14 MW installed capacity) of 12 MW total capacity to the distribution grid had been commissioned by 2005.

Table 1
FiT rate under SREP programme.

RE	Price RM/kWh (USD/kWh)
Biomass	
Year 2002	0.17 (0.052)
Year 2006	0.19 (0.058)
Year 2007	0.21 (0.064)
Biogas	0.17 (0.052)
Year 2002	0.17 (0.052)
Year 2006	0.19 (0.058)
Year 2007	0.21 (0.064)
Solar	–
Mini-hydro	
Year 2002	0.17 (0.052)

Since 2001, under SREP programme, the FiT rate was capped at RM 0.17/kWh (USD 0.052/kWh), then revised to RM 0.19/kWh (USD 0.058/kWh) in 2006 and again to RM 0.21/kWh (USD 0.064/kWh) in 2007 for biomass and biogas. This is as shown in Table 1.

The low tariffs have encouraged biomass and biogas electricity generation under SREP programme, but have not attracted much investment for other RE such as wind and solar as they require higher FiTs. Even though earlier FiT mechanism under SREP programme does not gain much success across all types of RE, the setting is expected to change beyond 2011.

During the National Photovoltaic Conference in November 2009, PTM presented a full FiT scheme which will be introduced to the Malaysian parliament in November 2010 for the 10MP period [5]. It is estimated that the FiT scheme would add 2% to the average electricity tariff in the country. The proposed tariffs will be differentiated by technology and project size as tabulated in Table 2. The tariff ranges from 0.23 to 1.75 (in RM/kWh) or 0.07–0.54 (in USD/kWh) for payback duration between 16 and 21 years.

The FiT scheme has been proven successful in accelerating RE deployment, reducing the carbon emissions and creating jobs in many countries such as Germany, Italy, Spain and Thailand as reported by Malaysian Energy, Green Technology and Water (MEGTW) Minister Peter Chin Fah Kui after attending the Conference on Sustainable Buildings Southeast Asia 2010, held in Kuala Lumpur. The FiT scheme is expected to curb 42 mil tonnes of carbon dioxide (tCO_2) from power generation by 2020 and 145 mil tCO_2 by 2030.

To make FiT possible, the RE law under the RE policy must make sure that: (i) RE electricity generated must have access to the utility distribution grid, (ii) FiT must be high enough to produce a return on RE investment, (iii) FiT must be fixed for a long enough period to give certainty and provide businesses with the security for RE market development, (iv) there must be a degression for the FiT to promote RE cost reduction in achieving grid parity, and (v) adequate fund is created to pay for the incremental tariff cost and guarantee the payment for the whole contract period, and (vi)

Table 2
Proposed full FiT rate.

RE	Duration (year)	Tariff[a] RM/kWh (USD/kWh)	Annual degression[a]	Displaced electricity cost[b] RM/kWh (USD/kWh)
Wind	21	0.23–0.35 (0.07–0.11)	1%	0.22 (0.07)
Solar PV	21	1.25–1.75 (0.39–0.54)	6%	0.35 (0.11)
Solid waste and sewage gas	21	0.30–0.46 (0.09–0.14)	1.5%	0.22 (0.07)
Biomass	16	0.24–0.35 (0.07–0.11)	0.2%	0.22 (0.07)
Biogas	16	0.28–0.35 (0.09–0.11)	0.2%	0.22 (0.07)
Geothermal	21	0.28–0.46 (0.09–0.14)	1%	0.22 (0.07)
Mini-hydro	21	0.23–0.24 ($\sim$0.07)	0%	0.22 (0.07)

[a] Subject to final confirmation upon enactment of RE law.
[b] Subject to tariff increment.

Table 3
Electricity capacity generated under SREP programme.

RE	Company	Export capacity (MW)
Biomass[a]	TSH bioenergy[b]	10
	Kina biopower	10
	Seguntur energy	10
	Recycle energy	5.5
Biogas	Jana landfill[b]	2
Mini-hydro	Esajadi power	2
	AMDB	4

Source: PTM.

[a] Empty fruit bunch and municipal solid waste.
[b] Commissioned as of 2005.

competent agency to implement FiT must ensure constant monitoring, reporting and transparency [6].

3. RE potentials

Earlier potential of FiT scheme has been rather low under SREP programme. Initially, SREP programme targeted to contribute 5% (600 MW) of the country's electricity demand by 2005 but only a total of 12 MW capacity to the distribution grid had been commissioned by 2005. As of July 2009, according to PTM, a total of 43.5 MW was generated and connected to the distribution grid from SREP programme as shown in Table 3 [7]. The electricity generation focuses mainly on biomass (including solid waste), biogas, and mini-hydro.

From [8], the energy potential of RE in Malaysia beyond 2010 (except for wind and geothermal) is as shown in Table 4. This is assuming that the RE policy and action plan has been successfully implemented. From the table, the potential cumulative installed capacity of biomass will continue to rise to 1340 MW in 2050 from 110 MW in 2011. A greater potential is seen from solar energy, from merely 9 MW in 2011 to 18,700 MW in 2050, surpassing all other RE combined.

On the other hand, the annual RE electricity produced and annual CO_2 avoided increases from almost 1.3 to 25.6 TWh and 0.85 to 17.6 mil tonnes/year, from 2011 to 2050, respectively as shown in Table 5.

Fig. 1 shows the RE cumulative installed capacity against RE (business as usual) if RE policy and action plan have not been implemented [8]. Once the RE policy and action plan are successfully implemented, at least a quantum of 1000% of increment from business as usual is expected by 2050 to the installed capacity.

According to PTM, biomass and biogas, mini-hydro and solid waste will be prioritized as RE sources under the RE policy. Wind and geothermal sources will play a secondary role while solar energy has been identified as the next growth area, expected to surpass the primary RE sources. According to the World Energy Outlook 2009 [9], non-hydro modern RE technologies (including wind, solar, geothermal, etc.) will see the fastest rate of increase mostly in power generation. Wind, geothermal and solar energy are considered as green power technology as it has only minor impacts on the environment. The energy plants produce no air pollutants and greenhouse gases (GHGs). In Malaysia, wind and geothermal power generations are not as mature as biomass. With the implementation of FiT under the RE policy, Malaysia aims to increase RE contribution against its total electricity generation by 6% in 2015 and 11% by 2020 as shown in Fig. 1. According to [6], with the implementation of RE policy, by the year 2020, there is a potential of:

1. Minimum RM 2.1bil (USD 0.65bil) savings of external cost to mitigate CO_2 emission (total 42 mil tonnes from 2011 to 2020, on the basis of RM50/tonne of external cost).
2. Minimum RM 19bil (USD 5.8bil) of loan value for RE projects.
3. Minimum RM 70bil (USD 21.5bil) of RE business revenues generated from RE power plants operation (which can generate income of RM 1.75bil (USD 0.5bil) to government, on the basis of 10% profit value where income tax is 25% on profit).
4. Minimum 52,000 jobs created (on the basis of 15–30 job/MW).

3.1. Wind

In 2005, worldwide capacity of wind-powered generators was 58,982 MW, their production making up less than 1% of worldwide electricity use. Denmark, Portugal and Germany are global leaders

Table 5
RE electricity and CO_2 avoided [8].

Year	Annual RE electricity (GWh)	Annual CO_2 avoided (tonnes/year)
2011	1228	846,975
2015	5374	3,707,825
2020	11,227	7,746,837
2025	14,662	10,117,015
2030	16,512	11,393,197
2050	25,579	17,649,620

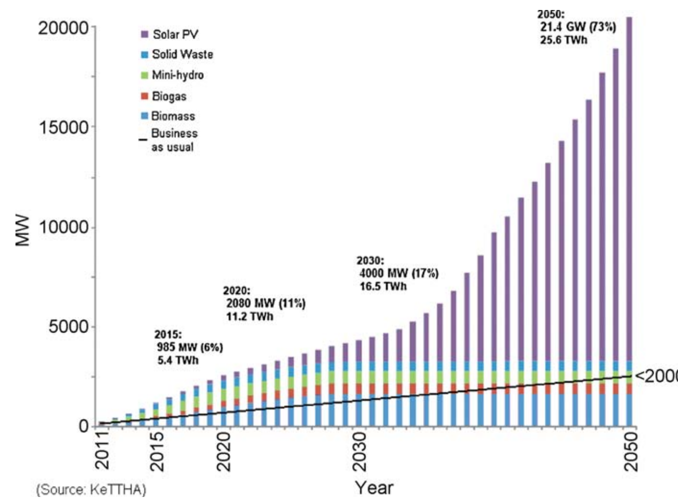

Fig. 1. Cumulative RE installed capacity.

Table 4
Energy potential of RE in Malaysia [8].

Year	Cumulative RE installed capacity in MW							
	Wind	Solar	Solid waste	Biomass	Biogas	Geothermal	Mini-hydro	Total
2011	–	9	20	110	20	–	60	219
2015	–	65	200	330	100	–	290	985
2020	–	190	360	800	240	–	490	2080
2025	–	455	380	1190	350	–	490	2865
2030	–	1370	390	1340	410	–	490	4000
2050	–	18,700	430	1340	410	–	490	21,370

in wind energy. Wind energy generation in Malaysia depends on the availability of the wind resource that varies with location. Not many literatures are available on wind energy potential in Malaysia and Malaysia has yet to have any wind power plant connected to the grid. In the early 1980s, the Solar Energy Research Group from Universiti Kebangsaan Malaysia (UKM) collected data from ten stations distributed all over Malaysia (six in Peninsular and four in East Malaysia) for a 10-year period between 1982 and 1991. All the stations were located either at airport, near open sea, flat area or meteorology department. The station located at the seaside of Mersing (in Peninsular) showed the greatest potential with a mean power density of 85.61 W/m^2 at 10 m above sea level [10]. It was reported in another study [11] that the annual offshore wind speed in Malaysia is around 1.2–4.1 m/s with higher values occurring in the east peninsular Malaysia having 3.3–4.1 m/s. Malaysia's wind energy potential seems to be low as wind speed is rather low. In 2005, a 150 kW wind turbine in Terumbu Layang Layang was demonstrated with some success by a team from UKM [12]. Recently in 2009, the minister of MEGTW was reported saying that GoM is looking at the potential of wind energy and will carry out tests in a number of areas to assess its viability. This can then be followed with detailed assessment. Hence, to this moment, the potential of wind energy in Malaysia remains rather low.

3.2. Solar

The tropical climatic condition in Malaysia is favorable for the development of solar energy or solar photovoltaic (PV) due to abundant sunshine with the average irradiance per year of 1643 kWh/m^2 [13]. A study conducted under Malaysia Building Integrated Photovoltaic (MBIPV) project showed that the potential in producing electricity through solar PV system in Malaysia was among the highest worldwide. Under MBIPV project, selected Malaysian cities as shown in Table 6 underwent solar measurements on annual energy output, energy payback time and CO_2 mitigation [14]. The study was similar to the one conducted by IEA-PVPS Task 10 in OECD cities [15].

From the study, it was found that: (i) the annual energy output for the selected Malaysian cities varies about 1170–1600 kWh/kWp for roof-top systems while about 630–830 kWh/kWp for facade systems, respectively. This makes Malaysian cities among the top half for the annual energy output estimated for roof-top applications among the cities surveyed as compared to [15]. The highest annual energy output from the study is Kota Kinabalu, (ii) the energy payback time ranges from 1.6 to 2.2 and from 3 to 4 years for roof-top systems and facade systems, respectively. This is considerably shorter than the expected 30 years lifetime of the installations and thus energy input for manufacturing and installation of PV systems can be recovered well before 30 years, and (iii) the CO_2 mitigation ranges from 20 to 40 tCO_2 for roof-top installations and from 10 to 20 tCO_2 for facade systems. Thus, CO_2 mitigation potential in Malaysia is relatively high.

Table 6
Selected Malaysian cities underwent solar measurements.

Region	City
Peninsular Malaysia	
Central	Kula Lumpur
Northern	Penang
Eastern	Kota Bahru, Kuantan
Southern	Melaka, Johor Bahru
East Malaysia	
Sabah	Kota Kinabalu
Sarawak	Kuching

The major player in solar power in the world is Germany. Germany installed about 3800 MW of solar PV power in 2009, almost half of the world market and expected to reach 4500 MW by 2010. Even with low sunshine (average global irradiance around 1000 kWh/m^2), Germany can be a global solar power player; Malaysia which is situated at the equator and has sunshine throughout the year is definitely going to play a significant role in solar power. From Table 4, by 2015, the estimated potential for electricity from biomass, biogas, mini-hydro and solid waste is estimated to be 330, 100, 290 and 200 MW, respectively. On the other hand, solar PV is estimated to have a cumulative capacity of 65 MW by 2015, lower than the other RE. But beyond 2020, it is predicted that solar energy will surpass all other forms of RE in Malaysia as illustrated in Fig. 1. By 2050, the total annual electricity generation from solar PV alone will contribute more than one third among all the RE. According to [16], currently there are four leading global PV enterprises in Malaysia – First Solar, Sunpower, Q-Cells and Tokuyama (refer Table 7) with a collective foreign direct investment (FDI) equivalent to RM 13.8bil (USD 4.2bil) and creating 10,700 high skilled jobs. By 2011, Malaysia is expected to emerge among the top five solar PV manufacturer worldwide, behind China and Germany with local PV industry contributing up to 4% to the national GDP by 2020 through revenues exceeding RM 500bil (USD 154.5bil). Therefore, the potential of solar energy, not only in electricity generation but also market development, is the brightest among all RE.

3.3. Solid waste

The solid waste management in Malaysia is directly under the federal GoM's jurisdiction through the Solid Waste and Public Cleansing Management Act 2007. Malaysia has developed a National Strategic Plan for Solid Waste Management that forms the basis for solid waste policy and practice in Peninsular Malaysia until 2020. In the Ninth Malaysia Plan (9MP), the government supports the adoption of sustainable waste management through reduction, reuse and recycling with the use of appropriate technologies, facilities, equipment and service standards. The 9MP also announced the establishment of a new entity, the Solid Waste Management Department, under the Ministry of Housing and Local Government, to undertake policy formulation, planning, and management [17]. Municipal solid waste (MSW) in Malaysia involves the disposal of approximately 95% of the total waste to landfills. The local authorities and waste management consortia have to handle approximately 17,000 tonnes of MSW everyday throughout the country [18]. The largest sources of MSW are domestic waste followed by industrial and commercial/institutional waste as depicted in Table 8. Table 9 shows the composition

Table 7
Information of FDI on solar technology.

Company	Origin	Location	FDI RM' bil (USD' bil)	Employee	Start
First Solar	US	Kulim, Kedah	2 (0.6)	1200	2008
Q-Cells	Germany	Selangor	5 (1.5)	3500	2009
Sunpower	US	Rembia, Melaka	5 (1.5)	5500	2010
Tokuyama	Japan	Bintulu, Sarawak	1.8 (0.6)	500	2011

Table 8
Composition of solid MSW by sector in Malaysia.

Sector	Weight (%)
Domestic	49
Industrial	24
Commercial/institutional	16
Construction	9
Municipal	2

Source: PTM 2008.

Table 10
Projected amount of MSW generated by 2020.

Year	Population	Estimated amount of waste (tonnes/year)
1991	17,567,000	4,488,369
1994	18,917,739	5,048,804
2015	31,773,889	7,772,402
2020	35,949,239	9,092,611

Source: PTM 2008.

of MSW by materials, in which organic, paper and plastics wastes composed up to 76%.

MSW contains significant portions of organic materials that produce gaseous products, an energy source known as biogas which is naturally produced from anaerobic degradation at landfills. According to [20], the main content of the landfill gas (LFG) is methane (CH_4), which can be used for power generation, transport and as cooking gas. Harvesting energy from landfills is befitting as there are more than 261 landfill sites in Malaysia and 150 sites are still operating, contributing to the immense potential of LFG formation. If the CH_4 is left untapped, it can become a major greenhouse contributor as CH_4 is 23 times more hazardous than CO_2 in terms of its global warming effects.

Currently, the Jana Landfill Gas Power Generation at Puchong (in Peninsular) is the first grid connected RE project in Malaysia. The construction was completed in November 2003 and commissioned in April 2004. The 2.096 MW power plant has two gas engines rated at capacity of 1048 kW and the landfill receives 3000 tonnes of garbage daily from major parts of Klang Valley, Peninsular Malaysia. The interconnection point of Tenaga Nasional Berhad (TNB-Malaysia's main electricity company) substation with the gas power generator is located 30 m from the site, with 2 MW being exported to the national grid. The well can produce biogas for a period of 20 years and the gas composition is more than 55% CH_4 gas with an 80% maximum moisture level at a production rate of 40 m^3/h [21]. Due to its high potential, an expansion to the plant has been planned.

Another method of solid waste disposal in Malaysia is through incineration. Incineration is seen as the easiest way to handle waste due to shortage of land for landfills. The calorific value of the Malaysian MSW ranged from 1500 to 2600 kcal/kg. The energy potential from an incineration plant operating based on 1500 tonnes of MSW/day with an average calorific value of 2200 kcal/kg is assessed to be at 640 kW/day. The average amount of MSW generated in Malaysia is 0.5 to 0.8 kg/person/day and has increased to 1.7 kg/person/day in major cities [22]. With the ever increasing population, it is projected that more than 9 mil tonnes of MSW will be produced a year by 2020. Today 5% of the waste is being recycled, very much less than those in developed countries, but the GoM aims to have 22% of the waste recycled by 2020. With the Malaysia's MSW projected to reach more than 9 mil tonnes/year by 2020 (as shown in Table 10), the opportunity and potential of RE generation through waste disposal in Malaysia is extremely high.

Table 9
Composition of solid MSW by material in Malaysia [19].

Materials	Weight (%)
Organic	47
Paper	15
Plastics	14
Wood/garden waste	4
Metal	4
Glass	3
Textile	3
Other	10

3.4. Biomass and biogas

Biomass and biogas energy are emphasis in the 9MP under the SREP programme. Biomass combustion for heat and power is a fully developed technology in Malaysia. Biomass technology offers economic fuel option as well as available disposal mechanism for agricultural, industrial and domestic wastes. Malaysia has abundant biomass waste resources (we will exclude municipal waste) coming mainly from palm oil, wood and agricultural industries. Table 11 shows the biomass resources potential as of 2005. According to [23], it is estimated that a total of about 2500 MW capacity can be expected from 25 mil tonnes of palm oil residues (empty fruit bunches, fibres and shells) and 39 mil m^3 of palm oil mill effluents (POME), used for power generation and cogeneration. In additional, there is also a substantial amount of unexploited biomass waste from logging, padi, sugar and other residues.

The palm oil industry accounts for the largest biomass waste production in Malaysia. The GoM has banned the incineration of biomass waste and thus biomass power generation and cogeneration have become an alternative for disposing such wastes. Most of the existing biomass combustion systems in Malaysia utilise low efficiency low-pressure boilers with cogeneration efficiency of less than 40%. An additional source of energy in palm oil mills is the biogas (mostly CH_4) produced in the anaerobic decomposition of POME, which is usually dissipated into the atmosphere. Nowadays, high-pressure boilers for efficient production of power and heat from the biomass resources are available such as dual fired boilers capable of burning palm oil waste as well as use the POME derived biogas as a supplementary fuel [23].

One notable RE project which was launched in 2002 under SREP programme was the Biomass Power Generation and Cogeneration in Palm Oil Industry (BioGen) project [24]. In 2006, following tender proposals, two demonstration projects under BioGen as its full scale model were selected: (i) MHES Asia Biomass Power Plant in Bahau, Negeri Sembilan with total 13 MW capacity which cost RM 79mil (USD 24.5mil), and (ii) Felda Palm Industries Biogas Project with a capacity of 0.5 MW which cost RM 8mil (USD 2.5mil) at the same location (both in Peninsular). By 2009, these projects delivered 10 and 0.5 MW to the grid, respectively. The Biogen project reported that the total potential for biomass and biogas mill wastes was indicated at 2600 MW per annum in 2005.

Malaysia and Indonesia are currently the world's largest producer and exporter of palm oil. On average, Malaysia produces about 47% of the world's supply of palm oil as depicted in Table 12. All Malaysian states produce palm oil. Over 75% of total area planted is located in just four states: Johor, Pahang, Sabah and Sarawak, each of which has over half a million hectares under cultivation as shown in Table 13. Of the 4,165,215 ha planted in 2006, 3,703,254 or 88.9% is classified as mature and in production [23]. Not all the palm oils in Malaysia have been tapped to generate electricity. By 2006, 50 palm oil mills (12%) in Malaysia had indicated their intention of developing plans to implement biomass power generation and cogeneration [23]. This number is expected to increase from the 397 operative palm oil mills in 2006. The biomass and biogas potentials in Malaysia are extremely

Table 11
Biomass resource potential.

Type	Production (ktonnes)	Residue	Residue generated (ktonnes)	Electricity potential (MW)
Oil palm	59,800	Empty fruit bunches	12,300	570
		Fibres	8750	1080
		Shells	3940	550
		POME	38,870 m^3	330
Padi	2141	Rice husk	471	72
		Padi straw	856	83.9
Sugar	1111	Bagasse	356	0
Wood	2,937,679 m^3	Sawn timber	1,692,718 m^3	50.11
	523,336	Plywood & veneer	121,000 m^3	3.6
	147,813	Moulding	75,600 m^3	2.2

Source: PTM, Comprehensive Biomass Study 2005.

bright and promising. With constant supply of palm oil residues, steady electricity supply through biomass and biogas energy is expected even in the next 30 years.

3.5. Geothermal

Indonesia has the biggest geothermal energy potential in the world estimated at 27 GW. The US and the Philippines are currently the largest geothermal energy producers globally at 2958 and 1931 MW installed capacity, respectively. Malaysia has yet to have any geothermal power plant, but there are many potential geothermal areas. According to [26], there are 79 confirmed geothermal manifestation areas, 61 in Peninsular Malaysia and 18 in East Malaysia (eight in Sarawak and ten in Sabah). Recently in 2009, it was reported that Tawau in Sabah has an electricity generation potential of up to 67 MW from geothermal resources following the discovery of a geothermal site by the Mineral and Geoscience Department. A reservoir of about 2000–3000 m below the earth's surface with water at temperatures of 220–236 °C was also found. Thus, under the 9MP, the GoM had allocated RM 1.5mil (USD 0.46mil) for geothermal research in Tawau and drilling is expected to start under the 10MP. The potential of geothermal energy in Malaysia although seems encouraging at this stage, but is not as much as the other RE. Other RE sources such as ocean/tide/wave energy is also categorized under the same FiT rate as geothermal.

3.6. Mini-hydro

In Malaysia, hydropower is used for water supply, flood control and irrigation as well as recreation such as fishing and swimming. It is already one of the main power sources in Malaysia. Since the late 1970s, many mini-hydro projects were undertaken in Malaysia based on run-of-the-river systems ranging from 0.5 to 1 MW capacity. As reported by UKM, there are 39 units with a total capacity of 16 MW in Peninsular Malaysia, seven units with a total capacity of 2.35 MW in Sabah and five units with a total capacity of 5 MW in Sarawak [12].

The annual surface runoff, groundwater recharge and evapotranspiration in Malaysia are estimated at 566, 64 and 360 bil m^3, respectively. The fresh groundwater storage is estimated at 5000 bil m^3. In 1998, 14% (around 2000 MW) of electricity generation is from hydropower as Malaysia receives annual rainfall totals of 990 bil m^3 [27]. Some of the major hydropower plants include the Sultan Mahmud Power Plant (400 MW), Temenggor Power Plant (348 MW) and Bakun Dam (2400 MW). Due to its natural hilly terrain, Malaysia is bestowed with great hydropower potential. However, recent changes in rainfall pattern and frequent occurrences of drought have adversely affected water supplies. This is further affected by high consumption of water for domestic, industrial and irrigation purposes. From [27], water demand reaches 14.8 bil m^3 in 2000 (constituting less than 3% of surface water resources available) and is expected to reach 20 bil m^3 by 2020. Thus, water resources in Malaysia are not prioritized for power consumption. Even though encouraging and mature in hydro-technology, mini-hydro potential is not expected to be the main catalyst under FiT.

3.7. Others

Apart from having sufficient RE resources in Malaysia, another factor which influences the potential of RE is government's encouragement and incentives provided. Fiscal incentives was

Table 12
Forecasted production of palm oil for the year 2000–2020 [25].

Year	Malaysia	Indonesia	World total
Annual production mil tonnes			
2000	10,100 (49.3%)	6700 (32.7%)	20,495
2001	10,700 (48.1%)	7720 (34.7%)	22,253
2002	10,980 (48.4%)	7815 (34.5%)	22,682
2003	11,050 (47.7%)	8000 (34.6%)	23,149
2004	10,900 (45.6%)	8700 (36.4%)	23,901
2005	11,700 (45.6%)	9400 (36.6%)	25,666
Five-year averages in mil tonnes			
1996–2000	9022 (50.3%)	5445 (30.4%)	17,932
2001–2005	11,066 (47.0%)	8327 (35.4%)	23,530
2006–2010	12,700 (43.4%)	11,400 (39.0%)	29,210
2011–2015	14,100 (40.2%)	14,800 (42.2%)	35,064
2016–2020	15,400 (37.7%)	18,000 (44.1%)	40,800

Source: Oil World 2020.
%: % of world total.

Table 13
Area planted with oil palm by state.

Region	Hectares
Peninsular Malaysia	
Johor	671,425
Pahang	623,290
Perak	348,000
Terengganu	164,065
N. Sembilan	161,972
Selangor	128,915
Kelantan	94,542
Kedah	76,329
Melaka	52,232
Penang	14,119
Perlis	258
East Malaysia	
Sabah	1,239,497
Sarawak	591,471
Total	4,165,215

Source: MPOB 2007, Review of the Malaysian Oil Palm Industry 2006, Tables 2 and 4.

Table 14
Fiscal incentives for RE.

Incentive benefits
Pioneer status
Provides exemption from income tax 25% on 100% of statutory income for 10 years. Accumulated losses and unabsorbed capital allowances incurred during the pioneer period can be carried forward and deducted against post pioneer income of the company.
Investment Tax Allowance
100% of qualifying capital expenditure incurred within a period of 5 years can be utilised against 100% of the statutory income for each year of assessment. Unutilised allowances can be carried forward to subsequent years until fully utilised.
Import Duty and Sales Tax Exemption (ID-STE)
Companies generating RE can also apply for ID-STE on imported machinery, equipment, materials, spare parts and consumables used directly in the generation process and that are not produced locally. For locally purchased machinery, equipment, materials, spare parts and consumables, full exemption is given on sales tax.

first provided in National Budget 2001 and subsequently upgraded in National Budget 2009. This includes (i) Pioneer Status, (ii) Investment Tax Allowance, and (iii) Exemption from payment of Import Duty and/or Sales Tax as shown in Table 14. More detail information may be obtained from [28]. Prior to the proposed FiT mechanism, as a preparation, other than the SREP programme, the GoM has also embarked on various projects on RE and energy efficiency (as described in [29]) such as Malaysian Industrial Energy Efficiency Improvement project (ending 2009), Malaysia Building Integrated Photovoltaic Technology Application project (ending 2010), Building Energy Efficiency programme. This has not only brought awareness towards RE generation and energy efficiency among the local utilities, household users, industrial consumers but also foreign investments. All necessary regulatory frameworks have been in place. The proposed full FiT mechanism has gone through very serious consideration and preparations by the GoM.

4. Global RE and FiT scenario

Global electricity supply by RE is predicted to surpass those by conventional energy such as oil, coal and gas. Wind and modern biomass are the main RE growth areas globally for the time being. Solar energy is expected to grow drastically beyond 2030 and contributing towards 25% of the electricity supply by 2050 and more than 60% by 2100 as illustrated in Fig. 2.

Year	Cumulative number	Countries/states/provinces added that year
1978	1	United States
1990	2	Germany
1991	3	Switzerland
1992	4	Italy
1993	6	Denmark, India
1994	8	Spain, Greece
1997	9	Sri Lanka
1998	10	Sweden
1999	13	Portugal, Norway, Slovenia
2000	14	Thailand
2001	16	France, Latvia
2002	20	Austria, Brazil, Czech Republic, Indonesia, Lithuania
2003	27	Cyprus, Estonia, Hungary, Korea, Slovak Republic, Maharashtra (India)
2004	33	Italy, Israel, Nicaragua, Prince Edward Island (Canada) Andhra Pradesh and Madhya Pradesh (India)
2005	40	Turkey, Washington (US), Ireland, China, India (Karnataka, Uttaranchal, Uttar Pradesh)
2006	41	Ontario (Canada)

Source: REN21, 2006

Fig. 3. Countries, states and provinces that have adopted FiTs.

According to a research published by the International Energy Agency, it is estimated that as the RE market doubles, the price of RE will be reduced by at least 20%. As the RE price reduces to that equal to the conventional fuel price, a country is said to have attained grid parity [30]. The FiT scheme has proven to be the most effective mechanism for the RE industry in making competitive clean energy compared to the conventional fossil energy. According to [31], a well designed and implemented FiT can: (i) support installations of different sizes and technologies, (ii) promote innovation, (iii) drive economies, (iv) promote stability, (v) promote public support, and (vi) create fair market participation conditions for every energy provider. FiT mechanism has been adopted by many countries in the world such as US, Spain, Germany, Thailand as shown in Fig. 3. For Germany alone, the adoption of FiT is said to have created 214,000 jobs and avoided 97 mil tonnes of CO_2 emissions in 2006 [31].

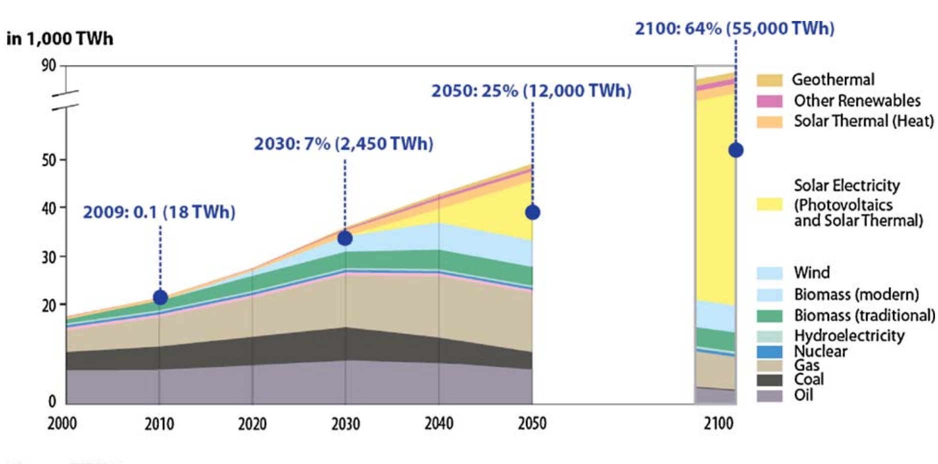

Fig. 2. Electricity supply by global renewable resources.

From the World Energy Outlook 2009, ASEAN countries including Malaysia are expected to play important role in global energy market for the decades ahead. The ASEAN primary energy demand is said to expand by 76% between 2007 and 2030 with annual growth rate of 2.5%, higher than the average rate in the rest of the world [9].

5. Conclusions

FiT mechanism provides stable investment climate and it has been proven to generate the fastest, lowest-cost deployment of RE [32]. Countries that have implemented FiT such as Germany, Spain and Thailand have created more employments, great investment market and security as it is non-depletable and also helps to reduce GHG emissions. Therefore, it is considered the most successfully implemented RE policy. In Malaysia, biomass and biogas energy (including solid waste) will continue to be the main RE sources for the next 20 years. Beyond that, solar energy is expected to rise drastically and be the main RE source surpassing all other RE combined. The GoM is already aware of the potential of solar energy and thus solar PV has been given a higher FiT rate. Solar energy, especially grid-connected PV will be the main market from 2015 onwards, provided FiT scheme is truly implemented from 2011 [16] and the minister of MEGTW was reported saying that solar energy will reach grid parity by 2017 [33]. As outlined by the National Renewable Energy Laboratory (NREL) in [34], several key factors will define the successful implementation of FiT: (i) stability – FiT has to be in place at least 5 years to encourage investments, (ii) long-term contract – sufficient time such as 15–20 years must be contracted to allow investors to recover their costs, (iii) adequate energy prices, (iv) annual decreasing payments to encourage rapid deployment and allows for competitions, (v) differentiate payments by technology, project size and resource, (vi) incorporate FiT into utility to guarantee payments, and (vii) proper regulatory framework. All of these seem to have been in place, only awaiting the GoM's enactment of the RE policy and the full FiT scheme is almost definite going to change the energy market and developments in Malaysia.

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